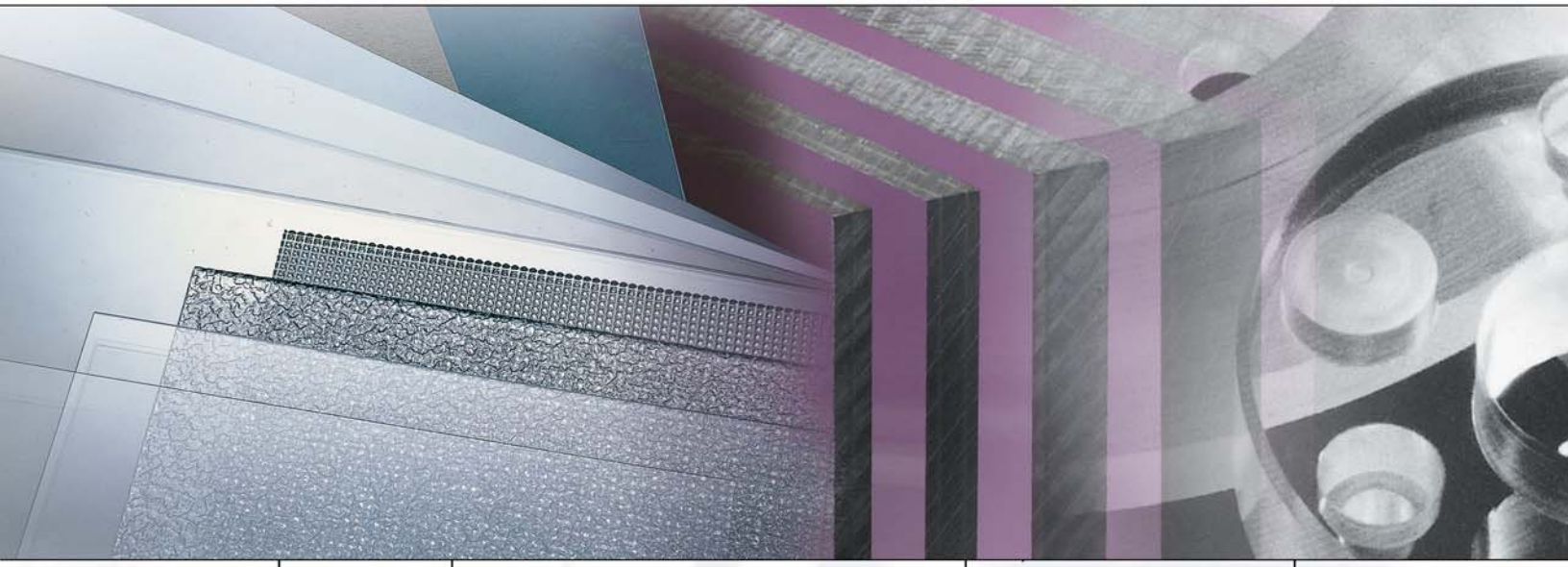
MAKROLON®

POLYCARBONATE SHEET



MADE WITH MAK
NONE TOUGHER NONE CLEARER

…Clearly the Right Choice

Fabrication Guide

Sheffield Plastics Inc.

A Bayer MaterialScience Company

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CURBELL PLASTICS

None Tougher–None Clearer MAKROLON® Polycarbonate Sheet…

"Made with MAK" for Quality and Excellence

Produced from Bayer Corporation's MAKROLON polycarbonate resins, Sheffield's MAKROLON Polycarbonate Sheet meets or exceeds the performance characteristics of any directly competitive product on the market today. Combining innovation with a desire for excellence and state-of the-art manufacturing, Sheffield Plastics Inc. produces a wide range of polycarbonate sheet products that are unsurpassed for clarity and toughness. With outstanding forming, fabrication, and performance characteristics, "None Tougher, None Clearer" MAKROLON Polycarbonate Sheet can be easily fabricated into products that last. When you need clarity, toughness, and endurance, be sure you choose "Made with MAK."

In addition to supplying quality products, leading technology, and industry leading technical support, Sheffield Plastics takes pride in having the highest rated distribution network in the industry. The Sheffield Plastics team is comprised of our local distributors backed by Sheffield manufacturing and product support personnel. When your application requires additional assistance, please contact our team of dedicated professionals who are always ready to assist you at **800-254-1707**.

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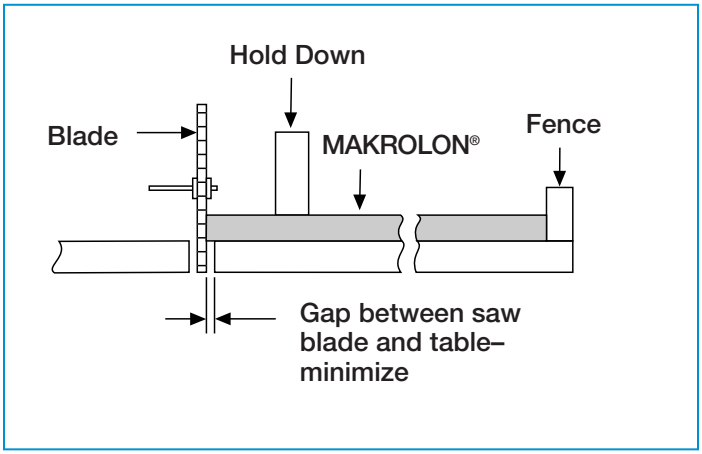
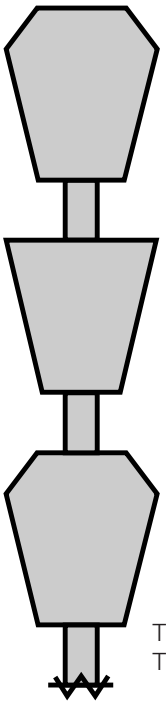
CIRCULAR SAWS

A circular saw blade with carbide teeth utilizing the "triple chip" tooth design is the preferred method of cutting MAKROLON® Polycarbonate Sheet. Table or overhead panel saws are normally used.

Circular saws should be run in the speed range of 6000-8000 ft/min. Blades for cutting 3/32″ and thicker material should have 3-5 teeth per inch. The hook or rake angle should be 10°-15°. When sawing thin-gauge MAKROLON Polycarbonate Sheet, it is important to have a good supporting edge on the saw table with minimal gap between the saw blade and table supporting edge. Be sure tabletops are smooth and free from projections that might scratch or mar MAKROLON Polycarbonate Sheet.





Triple Chip Alternate Tooth Design

CIRCULAR SAW TROUBLESHOOTING

PROBLEM: Melting or Gummed Edges

SUGGESTED SOLUTIONS:

1. Increase blade tooth size
2. Reduce saw speed
3. Increase feed rate
4. Use air to cool blade
5. Use blade lubricant compatible with MAKROLON Polycarbonate Sheet
6. Inspect blade for sharpness
7. Check blade-fence alignment
8. Reduce number of sheets in stack

PROBLEM: Chipping

SUGGESTED SOLUTIONS:

1. Decrease blade tooth size
2. Increase saw size
3. Provide better clamping and/or support for sheet stack
4. Reduce feed rate
5. Check blade and arbor for wobble
6. Inspect blade for sharpness

Router Bit Suppliers:

Dino Saw Company
340 Power Ave.
Hudson, NY 12534
Tel: (518) 828-9942

Onsrud
Libertyville, IL
Tel: (847) 362-1560

Bochco Inc.
Billerica, MA
Tel: (978) 667-1911

Saw Blade Suppliers:

Forrest Manufacturing
461 River Road
Clifton, NJ 07014
Tel: (800) 733-7111

General Saw Corp.
20 Wood Ave.
Secaucus, NJ 07094
Tel: (800) 772-3691

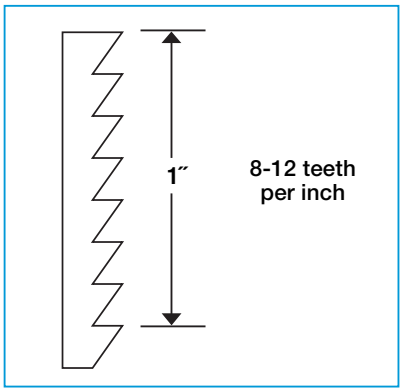
Dino Saw Company
340 Power Ave.
Hudson, NY 12534
Tel: (518) 828-9942

FTM, Inc.
6160 Cobblestone Rd.
Placerville, CA 95667
Tel: (916) 626-1986

BAND SAWS

Band saws are useful for trimming formed parts or irregular shapes. Band saws should be run at 2500-3000 ft/min and have 8-12 teeth per inch. Coarser (larger tooth) blades perform better with thicker gauge MAKROLON® Polycarbonate Sheet. Proper support of the part to be trimmed is important because vibration may induce cracking if the cut is not smooth. Sanding the edge smooth after cutting is recommended.

BAND SAW BLADE DESIGN



BAND SAW TROUBLESHOOTING

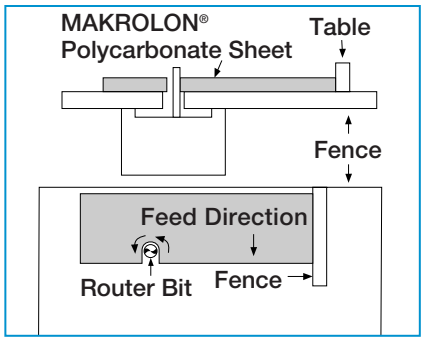
PROBLEM: Melting or Gummed Edges
SUGGESTED SOLUTIONS:
1. Increase tooth size
2. Reduce saw speed
3. Use air to cool blade
4. Check blade sharpness

PROBLEM: Chipping
SUGGESTED SOLUTIONS:
1. Decrease tooth size
2. Slow down stock feed rate
3. Provide better clamping and/or support to eliminate vibration
4. Check blade sharpness

ROUTING

Routing produces a smooth edge on MAKROLON Polycarbonate Sheet and may also be used to cut curved or irregular shapes. Routers with a speed of 20,000 to 25,000 rpm are preferred. Use straight (fluted 2 or 3) carbide-tipped or high-speed steel router bits. Bits should be 1/4″ to 1/2″ diameter for best results. Use a router with at least 1 H.P. motor.

Special care must be used when routing–Use proper guarding and eye protection. Stock feed rates must be monitored closely. Feeding MAKROLON Polycarbonate Sheet at excessive rates can cause vibration and cracking. It is important to feed the sheet against the rotation of the router bit and to provide a fence for sizing when making straight cuts.

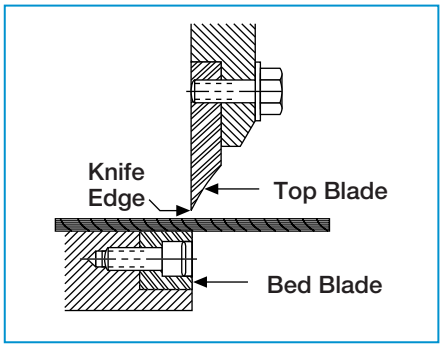


LASER CUTTING

MAKROLON Polycarbonate Sheet can be cut using industrial cutting lasers. Edges may become amber or brown when laser cutting. For information on laser cutting equipment and part cutting services, contact the manufacturer of your equipment or the suppliers listed on this page.

SHEARING

MAKROLON Polycarbonate Sheet may be sheared using a conventional sheet metal power shear. It is important to adjust the top blade clearance in relationship to the bed blade. A clearance of .001″ is desirable to avoid a rough edge cut. Shear single sheets only.



Laser Cutting Equipment Suppliers:

Coherent General
Picker Road
Sturbridge, MA 01566
Tel: (508) 347-2681

Laser Machine Inc.
500 Laser Drive
Somerset, WI 54025
Tel: (715) 247-3285

Laser Cut Parts:

Laser Engineering Inc.
444 North York Road
Elmhurst, IL 60126
Tel: (630) 530-0500

Laser Machine Inc.
500 Laser Drive
Somerset, WI 54025
Tel: (715) 247-3285

DIE CUTTING

Die cutting MAKROLON® Polycarbonate Sheet in gauges up to .080″ thick is normally achieved utilizing the following steps.

Steel rule dies mounted in a press provide good results. The shear strength of MAKROLON Polycarbonate Sheet is 10,000 psi which is appropriate for die cutting methods.

Calculating the required press tonnage to cut MAKROLON Polycarbonate Sheet:

$$F = \frac{P \times A}{2{,}000}$$

F= Required force in tonnage of the press
P=10,000 psi (shear strength of MAKROLON Polycarbonate Sheet)
A=The sectional area to be cut

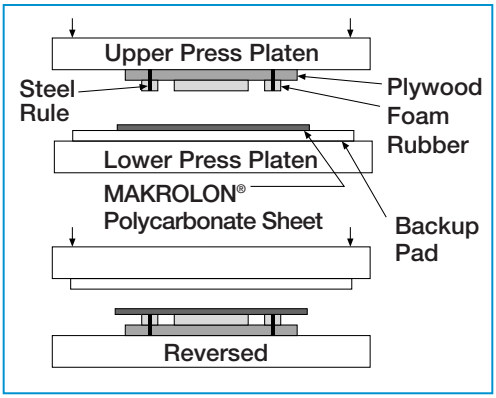
Example: Die cut 12″ x 20″ x .030″ thick rectangle
Total length of cut = 20″ + 20″ + 12″ + 12″ = 64″
Shear area = Total length x thickness (.030″)
or 64″ x .030″ =1.92 in^2
Required force = P = 10,000 psi

$$F = \frac{P \times A}{2{,}000} = \frac{10{,}000 \text{ psi} \times 1.92 \text{ in}^2}{2{,}000 \text{ lbs.}} = 9.6$$

Press tonnage (PT.) = 9.6

Use 3 PT. (.042″) thick steel to fabricate steel rule die. Flush or center bevel ground rule provides a clean cut. Facet ground steel rule is used to cut thicker gauge MAKROLON Polycarbonate Sheet (above .060″).

Be sure platens are parallel and that the backup pad is in good condition. Backup pads can be made from a wide variety of materials such as nylon, HDPE, etc.

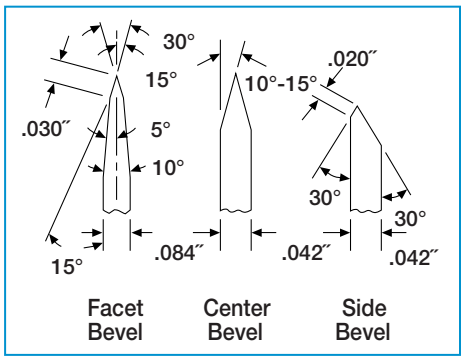


DRILLING

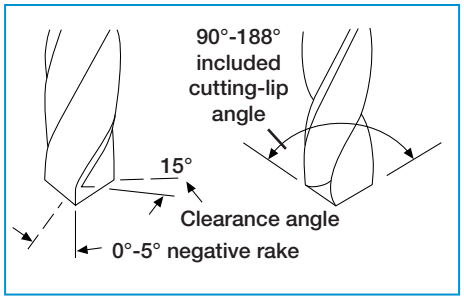
MAKROLON Polycarbonate Sheet is easily drilled using ordinary high-speed steel drill bits.

Regulate pressure and speed until a continuous spiraling chip is observed. Use air or water as a coolant if required. Using cutting oils may cause crazing. Be extremely careful if using taps or self-tapping screws; tapping creates notches that can result in stress cracks because polycarbonate is a notch-sensitive material, like most clear plastics. Recommended drill speed is 350-1750 rpm.

CROSS SECTION - BLADE GRINDS



DRILL BIT DESIGN



Hole Dia.	Drill Speed (RPM)
1/8″	1750
1/4″	1000-1500
1/2″	350-500

Die Cutting Equipment Suppliers:

National Steel Rule Die Co.
3580 Lightner Boulevard
Vandalia, OH 45377
Tel: (937) 667-3515
(937) 667-8407

Atlas Die, Inc.
2000 Middlebury Street
Elkhart, IN 46516
Tel: (219) 295-0050

Specialty Drill Bit Suppliers:

Craftics, Inc.
2701 N. Pulaski Road
Chicago, IL 60639
Tel: (773) 235-3307

FTM, Inc.
6160 Cobblestone Road
Placerville, CA 95667
Tel: (916) 626-1986

Forming

BRAKE BENDING

MAKROLON® Polycarbonate Sheet can be brake bent to 90° angles in gauges ≤ .100″. Attempts at bending heavier gauges can result in cracks or breakage at the time of bending or later due to high levels of stress in the bend area. For this reason strip heat bending is recommended on all gauges ≥ .118″.

COLD BENDING

MAKROLON® GP and MAKROLON® SL Polycarbonate Sheets may be cold-bent with the minimum radius based upon the sheet thickness. As a guideline, the material can be radiused to 100 times the thickness: (R=T x100).

COLD BEND RADII

Sheet Thickness (T)	Minimum Radius (R)
1/8″	12.5″
3/16″	18.7″
1/4″	25.0″

Note: MAKROLON® AR Polycarbonate Sheet is recommended for flat glazing only.

DRYING TIME (HOURS)

THICKNESS	250°F	180°F
.093″	4	8
.118″	6	14
.150″	8	20
.177″	12	30
.236	24	50

Note: MAKROLON® AR Polycarbonate Sheet is recommended for flat glazing only.

THERMOFORMING

MAKROLON Polycarbonate Sheet can be thermoformed on standard equipment. Vacuum forming, free blown forming, and line bending are the most extensively used processes.

While most standard forming techniques can be used, critical process modifications specific to polycarbonate are necessary to ensure uniform and repeatable formed parts.

PREDRYING MAKROLON® POLYCARBONATE SHEET

MAKROLON Polycarbonate Sheet must be dried before thermoforming because polycarbonate absorbs moisture at a high rate. Trapped moisture forms vapor above 250°F, and the vapor expansion creates bubbles in the sheet.

Sheets of MAKROLON Polycarbonate sheet should be placed in a dehumidifying air circulating oven for predrying. Temperature should be 250°F and monitored with controls. Recommended predrying time periods are shown below. Be cautious. Polycarbonate sheet begins absorbing moisture immediately upon removal from the predrying oven. The rate of absorption is dependent upon the ambient dew point. For this reason, it is crucial to transfer the sheet directly to the forming machine as quickly as possible.

FORMING EQUIPMENT

The thermoforming machine should be capable of generating and maintaining a vacuum of 20 in. Hg pressure throughout the thermoforming cycle.

Vacuum forming machines with infrared heating elements perform well for MAKROLON Polycarbonate Sheet forming. Rotary and shuttle designs with automatic or semi-automatic controls are most suitable. Key features of this type for equipment are timer control accuracy, uniform heating sources, and sufficient vacuum power. Single-sided heating has proven effective for MAKROLON Polycarbonate Sheet in gauges up to .177″. For thicknesses above .177″, it is recommended that dual-sided heating ovens be used for effective radiation penetration.

HEATERS

Infrared cal rod, coiled nichrome or ceramic heating elements provide the best heating sources. Gas-fired heaters or convection ovens are not normally used with polycarbonate. Uniform heating of the sheet is critical. Radiation absorption graphs for polycarbonate are available. These graphs help match the emissivity of the heating element with the sheet for the most efficient heat penetration.

HEATING CYCLE

Heating MAKROLON® Polycarbonate Sheet for vacuum forming requires heat penetration to achieve a 350°F to 360°F. The heat required will be higher for more complex shapes. When MAKROLON Polycarbonate Sheet reaches forming temperature, uniform "sag" occurs. The amount of sag depends on the size and thickness of the sheet. A 12″ x 12″ x .060″ sheet will sag approximately 1″. A 36″ x 36″ x .177″ sheet may sag 4″- 6″ at the center. Once uniform temperature has been achieved, timers can accurately reproduce the condition, and part-to-part consistency can be maintained.

PROCEDURE:

- Sheet thicknesses up to .177″ gauge can be heated from one side. Above .177″ gauge, two-sided heating is normally required to significantly enhance productivity.
- Heat source is removed and heated sheet is forced over or into mold where vacuum is applied.

HELPFUL HINT:

- MAKROLON Polycarbonate Sheet "sets up" very quickly compared to other thermoplastics and can be removed from the mold in a short period of time.
  Caution:
  MAKROLON Polycarbonate Sheet remains quite hot during this cycle and care must be observed when handling finished parts.
- Throughout the vacuum forming process, it is imperative that dust and dirt be controlled. MAKROLON Polycarbonate Sheet has a static charge that attracts foreign particles which can create surface imperfections. Molds also attract dust particles and should be cleaned to avoid creating surface defects.

SHADING OR SCREENING

Shading is often used to balance out hot spots in an oven for uniform temperature. Shading may also be used to control the sag of MAKROLON Polycarbonate Sheet during heating.

PROCEDURE:

- Use heavy-duty metal screening to shade the major portion of the clamped sheet, leaving several inches along the edges unshaded to compensate for cooler areas.
- Screens can be installed permanently or placed loosely above the sheet, depending on how much shading is required.

HELPFUL HINTS:

- Use slow heating. This is particularly important with heavier gauges in order to prevent gradient heating.
- Allow heat to reach uniformity at the center of the sheet.
- The heating rate may be reduced by lowering the heat intensity or by moving the sheet farther away from the heaters.

Thermoforming Troubleshooting

PROBLEM	POSSIBLE CAUSE	SUGGESTED SOLUTION
Bubbles or blisters	Too much moisture in sheet	- Predry sheet for longer time period - Check predry oven temperature
Pinholes or surface marks	Vacuum holes too large	- Use smaller diameter vacuum holes
Mark off	Mold surface too smooth	- Vapor hone or use extra fine emery cloth to lightly abrade mold surface
	Mold surface too rough	- Preheat mold
Sheet pulls out of damping frame during forming	Sheet too cold to form	- Heat sheet for longer time period
Non-uniform sag	Uneven heating	- Check heaters - Screen “hot” areas
Incomplete part formation detail	Sheet too cold Inadequate vacuum	- Heat sheet for longer time period - Check vacuum system for leakage - Increase vacuum
Webbing	Sheet too hot Improper mold spacing	- Reduce heating cycle - Redesign mold - Use mechanical assist/bridging

Thermoforming Machines:

Brown Machine
Division John Brown Plastics
330 North Ross Street
Beaverton, MI 48612
Tel: (517) 435-7741

Plasti-Vac, Inc.
214 Dalton Avenue
P.O. Box 5543
Charlotte, NC 28206
Tel: (800) 438-4139

Shuman Co.
P.O. Box 240906
Charlotte, NC 28244
Tel: (704) 525-9980

Drying Ovens:

Grieve Corporation
500 Hart Road
Round Lake, IL 60073
Tel: (847) 546-8225

MOLDS

In general, male molds are more suitable for vacuum forming. However, other factors such as part size, finish, and shape dictate mold design. Choice of mold materials should be determined by considering the length of the production run. For optimum cost-effectiveness, use the least expensive material that will take the entire run.

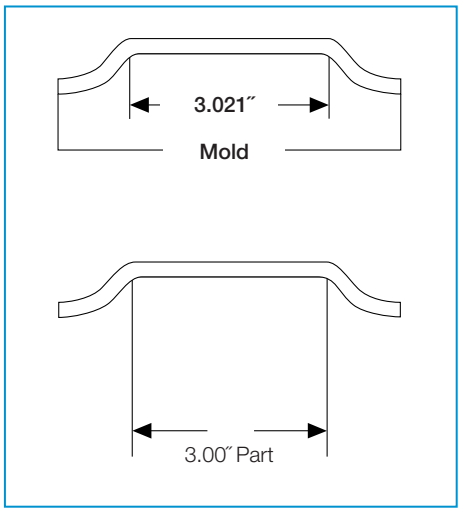
It is evident that thermal transfer is much more efficient with aluminum than wood. Wood, however, can be utilized for short-run projects.

MAKROLON® Polycarbonate Sheet reproduces mold surface finish accurately, even to the point of replicating wood grain in a smooth wood mold.

Sometimes it is desirable to reduce the polish on a steel or aluminum mold by utilizing a vapor hone or bead blast. This is due to the fact that if the mold surface is too smooth, air entrapment can occur creating "mark off." For best results, use fine hand sanding on the surfaces. Sanding provides tiny channels for air evacuation to prevent air entrapment. This may have to be repeated on long production runs, as the sanded finish smoothes out from extended use.

When constructing the mold, mold shrinkage should be a design consideration. Shrinkage for MAKROLON Polycarbonate Sheet is .005″-.007″. The heating/cooling cycle and the type of vacuum forming equipment will also influence results.

MOLD SHRINKAGE



MOLD MATERIALS AND MOLD DESIGN

MAKROLON Polycarbonate Sheet allows the use of a variety of mold materials: wood, filled and unfilled polyesters, epoxies, and metals.

Molds for vacuum forming need to take only 14 psi, so there is little wear on the tooling with low pressure of the material against the mold surface.

TYPICAL MOLD MATERIALS THERMAL CONDUCTIVITY PROPERTIES

Material	Heat Transfer Rate Factor	K Value btu/hr/sf/f/ft
Aluminum	6190	130
Steel	1238	26
Aluminum filled epoxy	24-47	.52-.87
Plaster of Paris	8.29	.17
Epoxy	6.24	.13
Wood (maple)	4.48	.09

MOLD DESIGN

Draft Angles: Minimum 5°-7° or greater for ease of part removal from the mold.

Radii and Fillets: Use generous radii wherever possible for more uniform walls and greater rigidity. On female tooling, use permanent corner fillets.

Vacuum Holes: In order to form the sheet as rapidly as possible, use sufficient holes for fast evacuation of air from between the sheet and the mold. In female molds, use air evacuation holes at all deep draw areas, especially around the mold perimeter where the sheet will be drawn last.

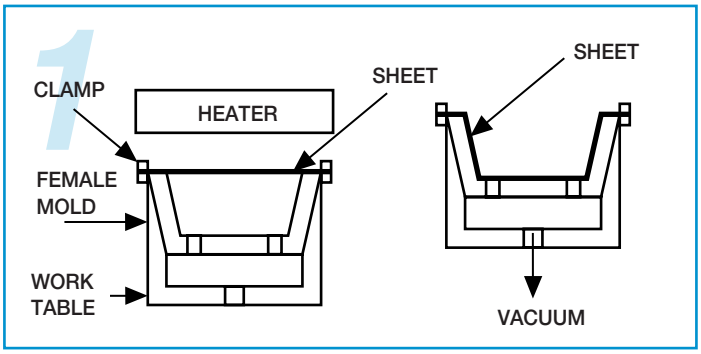
HELPFUL HINTS:

- Keep the diameter of the holes small (approximately 1/64″-1/32″ diameter) to avoid marking on the sheet. Long, thin slots may be designed for air evacuation in female tooling.
- Use vapor honed or fine sanded finishes.
- Avoid sharp corners to minimize stress.
- Avoid highly polished surfaces that can cause mark off.
- Always preheat mold. Cold molds can create surface defects and/or warped parts.
- If mold temperature becomes too high during thermo-forming runs, MAKROLON Polycarbonate Sheet could stick to the mold. It is recommended that the mold temperature not exceed 260°F.

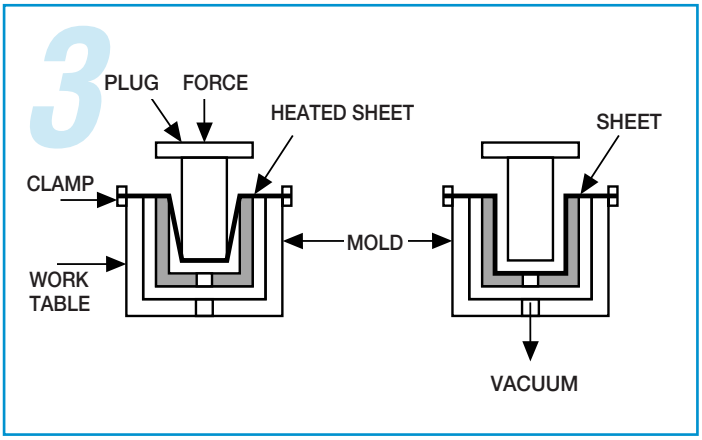
FORMING GUIDELINES

Sheet Temperature:

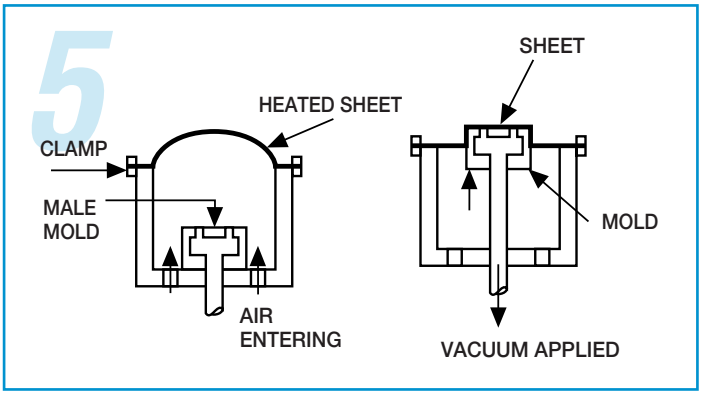
Typical:	340°F-380°F
Optimum:	350°F-360°F
Mold Temperature:	210°F-260°F



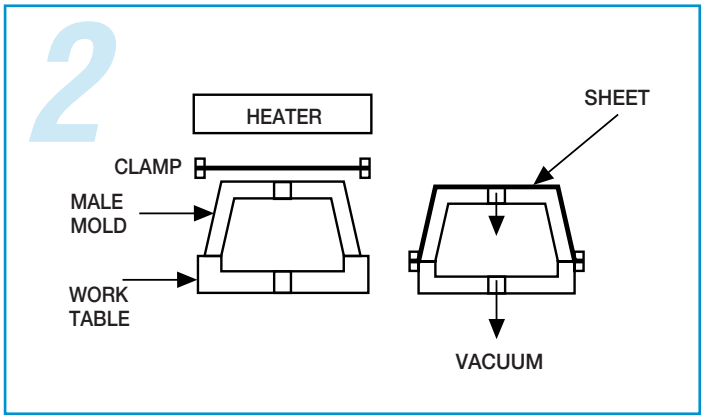
Straight vacuum forming in a female mold is recommended for low-profile parts where deep draw is not a requirement.



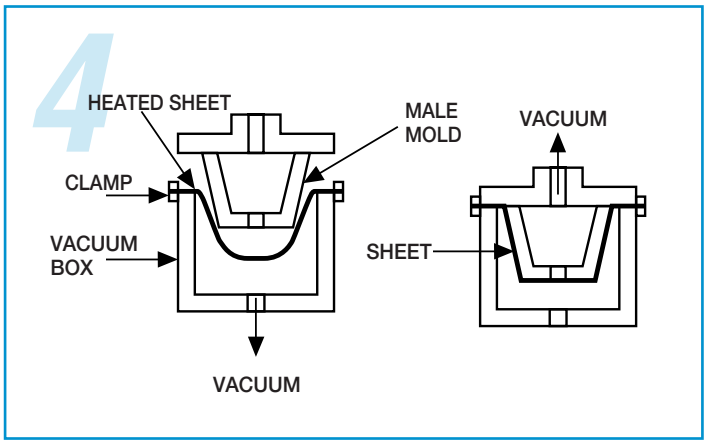
Thinning of material in deep-mold cavities can be overcome by use of plug assists designed for fast penetration.



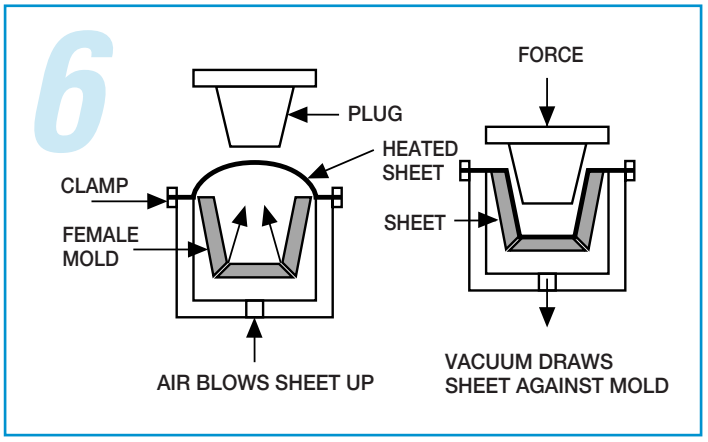
Air-slip forming is similar to vacuum snap-back except that heated sheet is billowed up and mold rises to meet it.



Drape forming over a male mold usually results in better material distribution and depth-to-diameter draw ratios.



Vacuum forming with snap-back can reduce starting sheet size, aid material distribution, and minimize chill marks.



Forming with billow plug is often used to produce thin-wall items with depth-to-diameter draw ratios up to 1.5:1.

FREE BLOWN BILLOW FORMING OF DOME

This process is utilized for forming dome shapes from MAKROLON® Polycarbonate Sheet. The procedures and equipment are the same as vacuum forming with the exception of the mold. Billow forming can be done with positive air pressure (free blown) or negative pressure (vacuum).

PROCEDURE:

- Preheat all clamps and tooling (240°F-260°F).
- Predry MAKROLON Polycarbonate Sheet in air circulating oven at 250°F. (See page 7 for recommended drying times.)
- Place MAKROLON Polycarbonate Sheet in clamping frame of thermoforming machine.
- Heat sheet until uniform sag occurs (340°F-380°F).
- Remove heat source.
- Lower pressure box to seal air supply pressure.
- Apply air pressure. Initial air pressure is high, and as dome is created, air pressure is reduced.
- When overall height is achieved, maintain positive air pressure until part cools.
- Be sure air source is properly filtered and uniformly dispersed for even formation of dome.
- Utilize electric eye designs or microswitches to assure consistent product.
- When dome reaches electric eye, set height. The eye controls air pressure through a solenoid valve to control cooling.
- Remove and trim.

FREE DRAWN VACUUM DOME FORMING

Follow steps involved in vacuum thermoforming, including predrying.

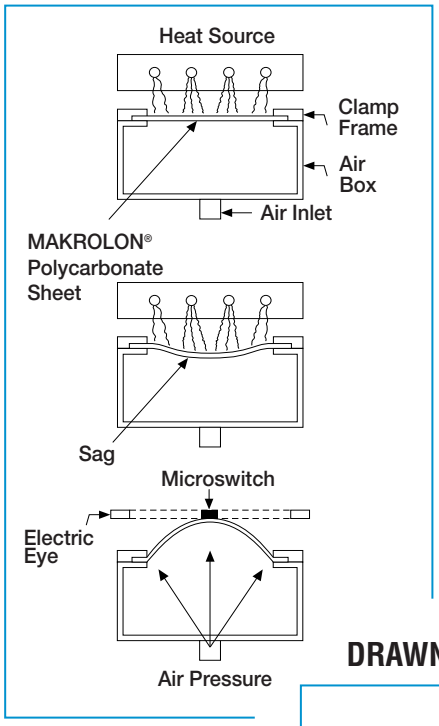
PROCEDURE:

- Place sheet in clamping frame of thermoforming machine.
- Heat sheet until uniform sag occurs (340°F-380°F).
- Remove heat source.
- Apply vacuum seal box and apply vacuum pressure.
- Use electric eye or microswitch to assure consistency of depth of dome.
- Retain small amount of vacuum pressure until dome sets up.
- Remove and trim.

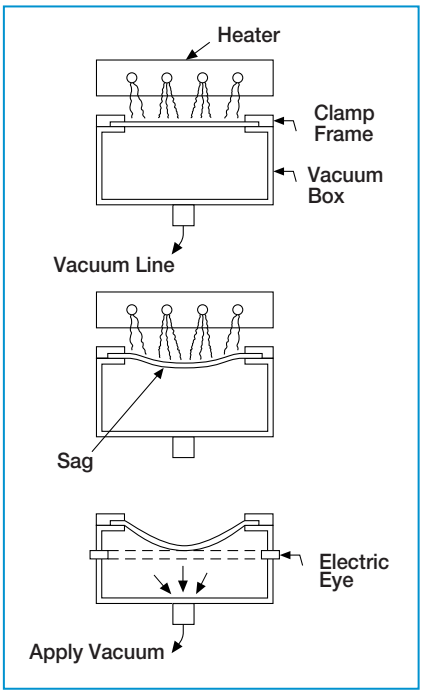
REGISTRATION FORMING

MAKROLON Polycarbonate Sheet is suitable for registration vacuum forming. Because the material is extruded, it is important to orient the sheet so that each part is screened and formed in the same direction each time. Material should be specially ordered for this application. Dimensional stability tests indicate MAKROLON Polycarbonate Sheet in free form releases stress about 2-4% in the direction of extrusion and 1% across the extrusion web.

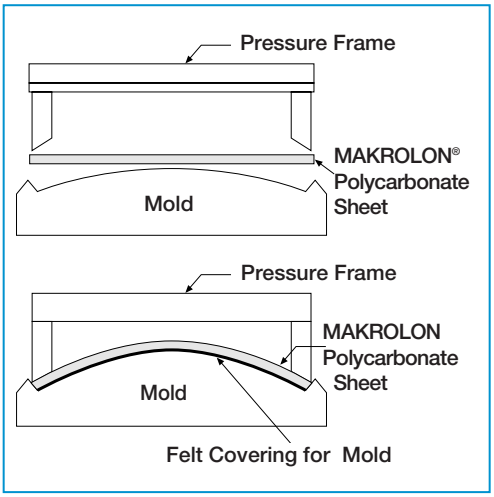
BLOWN DOME FORMING



DRAWN DOME FORMING



DRAPE FORMING



DRAPE FORMING

Simple contours can be achieved by drape forming MAKROLON® Polycarbonate Sheet. This method can be utilized to manufacture a part requiring a simple radius of curvature. Mold material can be wood, fiberglass or aluminum covered with felt.

PROCEDURE:

- Predrying MAKROLON Polycarbonate Sheet may not be necessary.
- Bring to forming temperature of about 300°F-320°F in the oven.
- Remove parts and immediately place over a male mold covered with felt.
- Apply pressure until cool.

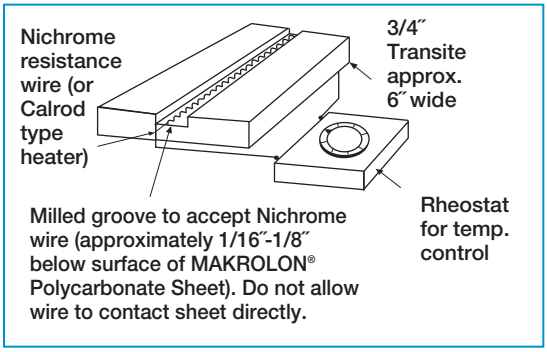
STRIP HEATING MAKROLON® POLYCARBONATE SHEET

Strip heating or line bending is commonly used for producing localized angular bends in polycarbonate. Generally, predrying is not required for material thicknesses of .118″ or less.

PROCEDURE:

- Remove protective masking in bend area.
- Regulate nichrome heat source to 340°F-365°F maximum.
- Place sheet over heat source at bend area.
- Allow heat to soften material–time depends on gauge.
- Remove sheet and make desired bend on wood or heavy fabric-covered aluminum fixture.
- Bend immediately–polycarbonate sets up quickly.
- Allow sheet to cool in fixture.
- Some bends may require a degree of overbending to achieve desired angle after sheet sets up. Strip heating works best for relatively short parts–wide parts may warp.
- Avoid bending short tabs on wide parts; warping may occur.
- For thicker gauge sheet, use two-sided heating. (Repeated turning with one-side heating may also achieve sufficient heat penetration.)
- Thicker gauge sheet (above 1/8″) can be grooved with a 1/16″ radius to allow sharper bends.

HEAT BENDING DEVICE


Nichrome resistance wire (or Calrod type heater)
3/4″ Transite approx. 6″ wide
Rheostat for temp. control
Milled groove to accept Nichrome wire (approximately 1/16″-1/8″ below surface of MAKROLON® Polycarbonate Sheet). Do not allow wire to contact sheet directly.

STRIP HEATING TROUBLESHOOTING

PROBLEM: Bubbles in bent area
POSSIBLE CAUSE: Too much heat
SUGGESTED SOLUTION: Reduce temperature

PROBLEM: Warpage
POSSIBLE CAUSE: Part too wide for heat bending
SUGGESTED SOLUTION: Heat from both sides to provide more uniform heat penetration

PROBLEM: Heating not uniform
SUGGESTED SOLUTION: Check for air drafts which may affect uniform cooling

PROBLEM: Cooling not uniform
SUGGESTED SOLUTION: Do not try to bend short (under 1″) sections

PROBLEM: Mark off
POSSIBLE CAUSE: Heater is contacting plastic. Transite is too hot. Masking is not removed over sufficient area where heat is being applied
SUGGESTED SOLUTION: Lower heat source

Strip Heaters:

FTM Inc.
6160 Cobblestone Road
Placerville, CA 95667
Tel: (916) 626-1986

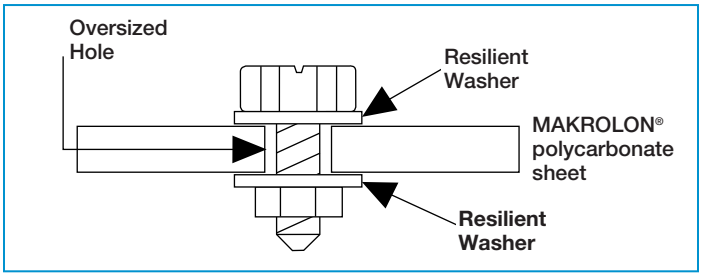
C.R. Clark & Co.
4407 Vineland Road D5
Orlando, FL 32811
Tel: (800) 676-7133

Craftics Inc.
2701 N. Pulaski Road
Chicago, IL 60639
Tel: (773) 235-3307

MECHANICAL FASTENING

Aluminum rivets and machine screws may be used to join MAKROLON® Polycarbonate Sheet to other materials by utilizing proper attachment methods.

Drill oversized holes and use washers to distribute and cushion localized stress. Be sure to consider differentials in expansion factors for dissimilar materials. Be sure drilled holes are smooth and free from cracks.



SOLVENT BONDING

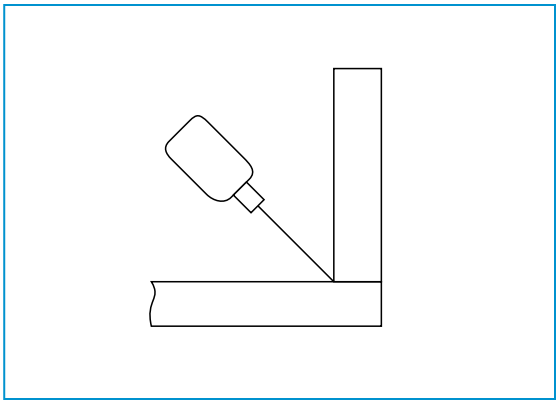
Many applications for MAKROLON Polycarbonate Sheet involve fabrication of sheets to construct three-dimensional shapes.The most popular method is to solvent bond. MAKROLON Polycarbonate Sheet solvent bonding can be achieved using methods employed in fabricating other thermoplastics such as acrylic. The two most common methods are needle type applicator capillary action and edge dipping. Both methods rely on smooth edge preparation, pressure, and curing.

It should be noted that solvent bonding will significantly reduce the strength of polycarbonate.

PROCEDURE:

- Smaller items with flat surfaces can be bonded by placing the pieces together and applying the solvent along the edges using a needle applicator or hypodermic syringe. Make sure the solvent flows along the entire joint.
- For bonding larger items, immerse the surfaces to be joined in the solvent until the material is softened.
- Clamp them in position and hold until the bond is set.

NEEDLE APPLICATOR



HELPFUL HINTS:

- Edges must be clean and free from dirt.
- Surfaces should be smooth and properly aligned.
- Apply even pressure to reduce bubbles in the bond area.

TECHNIQUES TO REDUCE WHITENING:

1. Fabricate in a climate-controlled area with low relative humidity.
2. The addition of 10% glacial acetic acid in the solvent reduces whitening.
3. Thickening the solvent with polycarbonate resin or sawdust promotes slower curing and reduces whitening.
4. Joint cure time is somewhat longer than acrylic. Be sure to retain fixture pressure until the joint is solid.

Note: Use extreme caution when working with solvents. Adequate ventilation is essential. Control exposure levels according to OSHA guidelines. Obtain Material Safety Data Sheets from the solvent manufacturer.

Adhesive Suppliers:

Industrial Polychemical
Weld-On Adhesives
17109 South Main Street
Gardena, CA 90247
Tel: (800) 421-2677

Pacer Technology
9420 Santa Anita Ave.
Rancho Cucamonga, CA 91730
Tel: (800) 538-3091

Hartel Enterprises
12970 Branford
Pacoina, CA 91221
Tel: (818) 767-0861

Lord Corp.
2000 West Grandview Blvd.
Erie, PA 16514
Tel: (814) 868-3611

Dow-Corning Corporation
3901 South Saginaw
Midland, MI 48640
Tel: (517) 496-4000

General Electric Company
260 Hudson River Road
Waterford, NY 12188
Tel: (518) 237-3330

Ciba Specialty Chemicals Performance Polymers
4917 Dawn Avenue
East Lansing, MI 48823
Tel: (800) 367-8793 • www.loctite.com

MAKROLON® POLYCARBONATE SHEET ADHESIVE GUIDE

ADHESIVE	JOINS MAKROLON SHEET TO	COMMENTS	COLOR	1-OR 2-PART SYSTEM	APPLICATION METHOD	SETUP TIME	CURE TIME	SUPPLIER
Methylene Chloride	MAKROLON Polycarbonate Sheet Acrylic	- Clear Solvent - High tensile strength products - Low-impact resistance	Clear	One	Flow	20 sec.	48 hrs @ 75°F	Chemical Supply House
Weld-On Series	MAKROLON Polycarbonate Sheet Butyrate	- Various viscosities offering quick bonds	Clear	One	Flow	1 min.	24 hrs.	IPS/Weld-On
Urethane	Virtually Anything	- Clear, flexible high-impact bond - Excellent peel strength - Excellent shear strength	Clear	Two	Flow	8 hrs. @ 75°F	5 hrs. @ 150°F or 7 days @ 75°F	Hartel Enterprises, Inc. Formulated Systems Group
RTV Silicone	Metal/Plastic/Wood	- Excellent heat resistance - Good thermal expansion	Various Colors	One	Tubes, Caulkers	60 min. @ 75°F	24 hrs.	Dow-Corning GE Silicones

TRANSFER TAPE BONDING

Achieving a strong edge bond using solvents on thin-gauge thermoplastics is extremely difficult due to the reduced size of the bond area. Structural bonding of thin-gauge MAKROLON® Polycarbonate Sheet can be accomplished, however, by utilizing acrylic-based transfer tapes along with slight design modifications.

PROCEDURE:

- Bend a small return on the appropriate part to be fastened approximately the width of the transfer tape.
- Clean tape contact areas with 50/50 isopropyl alcohol-water mixture.
- Apply transfer tape to the return.
- Remove tape masking and press the part into place.

HELPFUL HINTS:

- Rolling the bonded area with a small wood or rubber roller improves bond strength.
- A nonstick slip sheet is useful for proper positioning of large or hard to handle parts.
- Peel strength of long, lineal bonded areas can be increased with the addition of a mechanical fastener at both ends of the bond.

WELDING

While mechanical fastening and solvent bonding are the most often recommended methods for joining plastics, another alternative is welding. Ultrasonic, radio frequency, and spin welding have proven to be appropriate. Contact manufacturers of ultrasonic welding equipment for recommendations on section and joint design.

Transfer Tape Suppliers:

3M/Industrial Specialties Division
3M Center, Bldg. 220-7E-01
St. Paul, MN 55144-1000
Tel: (800) 227-5085

Norton Performance Plastics
1 Sealant Park
Granville, NY 12832
Tel: (518) 642-2200

Ultrasonic Welding Equipment:

Vinton Inc.
1001 Lehigh Station Road
Henrietta, NY 14467-9311
Tel: (716) 359-3100

Branson Ultrasonics Corp.
41 Eagle Road
Danbury, CT 06813-1961
Tel: (203) 796-0400

SANDING

MAKROLON® Polycarbonate Sheet can be sanded using both wet and dry techniques. Gumming can result from dry sanding. Wet sanding produces a smooth finish. In both instances, the part will require further finishing in order to restore its high gloss.

MAKROLON Polycarbonate Sheet can also be buffed using a 2-wheel system. The first wheel uses a buffing compound to remove shallow scratches. The second buffing wheel is used for restoring the gloss.

JOINTING-PLANING

A standard woodworking jointer-planer is an excellent edge finishing machine for MAKROLON Polycarbonate Sheet. Blades must be carbide or high-speed steel. Avoid removal of too much stock on each pass. 1/64˝ or less stock removal normally yields the cleanest edge. Trying to remove too much material results in a rough edge or cracking of the sheet.

If smoother edges are required, wet sanding with fine grit sandpaper is recommended.

SOLVENT POLISHING

In order to improve the look of saw-cut edges, begin by sanding the edges smooth. For smoother, glossy edges, consider solvent polishing with MEK or methylene dichloride. To prevent humidity blush after drying, it may be necessary to add a small amount of a slow-drying component such as diacetone alcohol or glacial acetic acid. Since MAKROLON Polycarbonate Sheet has such good chemical resistance properties, keep in mind that solvent polishing cannot be expected to totally eliminate sand marks from the sheet edge.

Note: Use extreme caution when working with solvents. Adequate ventilation is essential. Control exposure levels according to OSHA guidelines. Obtain Material Safety Data Sheets from the solvent manufacturer.

HOT STAMPING

MAKROLON Polycarbonate Sheet is easily decorated by hot stamping. Normal operating conditions are: head (die) temperatures 375°F; dwell time 2-3 seconds at 60 psi.

Contact foil manufacturer for recommended application guidelines.

SCREEN PRINTING

Standard silk screening equipment with screens of varying mesh 8x-16x regulating the amount of ink coverage on MAKROLON Polycarbonate Sheet provides excellent sign product.

As with all thermoplastics, MAKROLON Polycarbonate Sheet must be clean and free from surface residuals prior to screening. Many screeners use a prerinse of 50% water and 50% isopropyl alcohol to clean the surface of MAKROLON Polycarbonate Sheet. Be sure to use soft nonabrasive cloths when cleaning to avoid scratching MAKROLON Polycarbonate Sheet. Ionized air also provides a good method for removing lint and dust.

After screening, separate sheets on a drying rack until ink is completely dry. DO NOT pack sheets for shipment until inks are dry.

UV cure inks can be used with heavy gauge MAKROLON Polycarbonate Sheet, but intense or prolonged UV may have a damaging effect on thin gauges. It is not recommended for MAKROLON Polycarbonate Sheet under .060 gauge as some loss of physical properties occurs.

PAINTING

Many paint systems are available for MAKROLON® Polycarbonate Sheet. As with screen printing it is important that the surface of the MAKROLON Polycarbonate Sheet be clean and free of surface residuals prior to painting. Many painters use a mixture of 50% water and 50% isopropyl alcohol to clean the surface of the sheet. Be sure to dry thoroughly prior to painting. Use a soft nonabrasive cloth or sponge to avoid scratching MAKROLON Polycarbonate Sheet. Conventional spray, spray masked, roller coat and brush are common application methods.

Avoid using paints containing toluene, xylene or solvents that will craze MAKROLON Polycarbonate Sheet. Be careful when using the paper masking for the design. Sharp knives can notch MAKROLON Polycarbonate Sheet and allow crazing to occur. Be sure not to allow razor knives to penetrate the MAKROLON Polycarbonate Sheet when cutting through masking paper.

A number of companies market paint systems for MAKROLON Polycarbonate Sheet and provide technical advice on application.

PAINT AND INK REMOVAL

Use caution when removing overspray or drips. Be sure that the solvent will not attack and craze polycarbonate. Isopropyl alcohol, VM&P naptha or similar solvents have been successfully used. Be sure to rinse with clear water after solvent application. Do not use scrapers, blades, knives, etc., as they will scratch MAKROLON Polycarbonate Sheet. Always test a small area and observe possible attack before subjecting large sheet to solvent.

NOTES ON MAKROLON® AR POLYCARBONATE SHEET

Coated sides of MAKROLON AR Polycarbonate Sheet cannot be painted because of the abrasion-resistant coating. However, sheet that is only coated on one-side (MAKROLON AR-1 Polycarbonate Sheet) can be reverse screened on the uncoated side using standard painting techniques for polycarbonate. This material is an excellent choice for durable graphics applications in high traffic areas.

Hot Stamping Foil Suppliers:

Transfer Print Foils, Inc.
9 Cotters Lane
East Brunswick, NJ 08816
Tel: (908) 238-1800
(800) 235-3645

Foilmark
40 Melville Park Road
Melville, NY 11747
Tel: (800) 645-9177

Crown Roll Leaf, Inc.
91 Illinois Ave.
Paterson, NJ 07503
Tel: (800) 631-3831

Screen Print Ink Suppliers:

Summit Screening
201 East 16th Avenue
North Kansas City, MO 64116
Tel: (800) 736-5959

NAZ-DAR Company
1087 N. Northbranch Street
Chicago, IL 60622
Tel: (800) 736-7636

Paint Suppliers:

Spraylat Corporation
716 South Columbus Avenue
Mt.Vernon, NY 10550
Tel: (914) 699-3030

Red Spot Paint & Varnish Co., Inc.
1016 East Columbia Street
Evansville, IN 47711
Tel: (800) 457-3544

Wyandotte Paint Products Co.
3295 River Exchange Drive
Suite 500
Norcross, GA 30092
Tel: (800) 233-2303

Mathews Paint Company
8201100 Street
Kenosha, WI 53142
Tel: (800) 323-6593

Glazing Information

INSTALLATION GUIDELINES

MAKROLON® Polycarbonate Sheet may be installed using wet or dry glazing systems. However, Sheffield warns against the use of PVC gasketing. The material may also be used for double-glazing or over-glazing applications for added insulation and security. Maintain adequate separation between the glazing panels to prevent touching during high humidity and/or high heat conditions.

INSTALLATION PROCEDURES

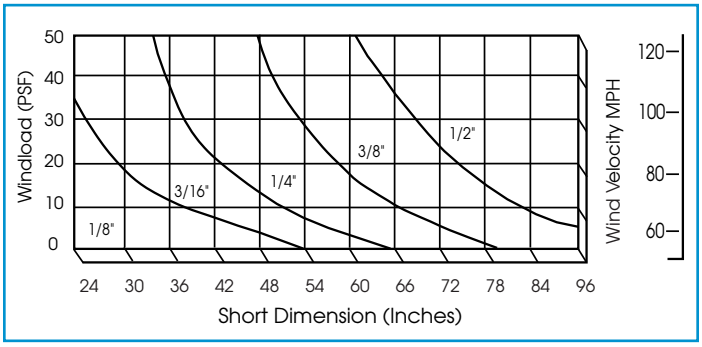
1. Clean sash and prime if necessary. For replacement glazing, make sure all old sealant and projections are removed. Rabbet should be free of burrs and of the proper depth to allow for expansion of the MAKROLON Polycarbonate Sheet glazing panel.
2. Carefully measure the sash opening. Determine the appropriate edge engagement and expansion allowance from Table (on next page). Cut MAKROLON Polycarbonate Sheet to the exact size required, making sure cut edges are smooth and free of chips and notches.
3. Glaze MAKROLON Polycarbonate Sheet with the proper compatible sealant. While smaller lites allow for the use of nonhardening oil-based and acrylic-latex caulks (up to 24˝ x 24˝), the thermal and load movements in larger sheet sizes require high performance, low modulus elastomers such as silicones.

RECOMMENDED SEALANTS, GASKETS, AND TAPES

Product Type	Product Name	Manufacturer
Silicone	Dow 795 Dow 999 Trademate®	Dow-Corning Corp Midland, MI (517) 496-4000
Silicone	Silpruf® Construction 1200®	General Electric Co. Waterford, NY (800) 255-8886
Silicone	Spectrem	Tremco Columbus, OH (800) 321-7906
Gasket	EPDM (60,70D)	Tremco Columbus, OH (800) 321-6357
Tape	440	Tremco Beechwood, OH (800) 321-7906
Gasket/Tape	Norrene® Foam V-2100 Urethane	Norton Company Granville, NY (518) 642-2200
Butyl Tape	Isocryl 5600	Schnee-Morehead Irving, TX (214) 438-9111

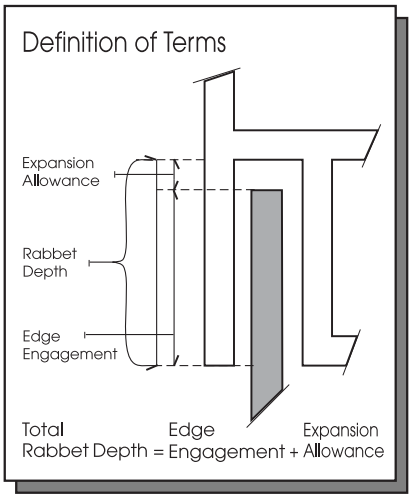
Many other glazing materials are commercially available which are compatible with MAKROLON Polycarbonate Sheet. Please contact those manufacturers for their recommended products.
Trademate is a registered trademark of Dow-Corning Corp.
Silpruf is a registered trademark of General Electric Company
Norrene is a registered trademark of Norton Company

WIND LOAD PERFORMANCE



EXPANSION ALLOWANCES–EDGE ENGAGEMENTS

Sheet Size	24″x24″	24″x36″	36″x48″	48″x60″
Expansion Allowance	1/8″x1/8″	1/8″x3/16″	3/16″x1/4″	1/4″x5/16″
Edge Engagement	3/8″	1/2″	9/16″	3/4″
Rabbet Depth	1/2″	11/16″	13/16″	1-1/16″



EXPANSION ALLOWANCES

As a general guideline, glazing systems should be designed to allow 1/16″ per foot of length and width as the expansion in the sash.

COMPARATIVE EXPANSION RATES

Material	in./in. °F
Glass	.0000050
MAKROLON® Polycarbonate Sheet	.0000375
Aluminum	.0000129
Steel	.0000063
Acrylic	.0000410

CLEANING AND MAINTENANCE

Thoroughly rinse with warm water using a soft cloth or sponge. Wash with mild soap or detergent and rinse thoroughly with clean water. To prevent water spots, thoroughly dry the glazing with a chamois or moist sponge. Do not use abrasive cleaners. Avoid cleaning in direct sunlight to prevent streaking.

COMPATIBLE CLEANERS

The following cleaning agents are compatible with MAKROLON Polycarbonate Sheet products when used according to the manufacturer's recommendations:

- Formula 409®
- Top Job, Joy®
- Palmolive Liquid®
- Windex D with Ammonia D®

Formula 409 is a registered trademark of Clorox Company
Top Job and Joy are registered trademarks of Proctor & Gamble
Palmolive is a registered trademark of Colgate Palmolive
Windex D is a registered trademark of Drackett Products Company

Product Selector

…Clearly the Right Choice

Product Features	MAKROLON® GP	MAKROLON® SN	MAKROLON® AR	MAKROLON® SL (SunLife)	MAKROLON® FI	Privacy Patterns	MAKROLON® CG	MAKROLON HYGARD®
Superior Impact Strength	★	★	★	★	★	★	★	★
Enhanced UV Resistance			★	★			★	★
Forced Entry Protection (UL 972)	★	N/A	★	★	★	★	★	★
Enhanced Abrasion Resistance			★				★	★
Thermoformable	★	★		★	★	★		
Cold-Formable	★	★		★	★	★		
Patterned Sheet	★	†				★		
Flame Inhibiting					★			
Bullet Resistant (UL 752)								★
Physical Attack Resistant			★				★	★

†MAKROLON® SN Polycarbonate Sheet is available with a matte finish.
MAKROLON® SL Polycarbonate Sheet is UL 48 Certified

COMPETITIVE OFF-SETS

MAKROLON® Grade	Description	GE Grade	AtoHaas Grade
MAKROLON® GP	General purpose grade for fabrication and glazing	LEXAN® 9030, 9034 DL 4630, DL 4634	TUFFAK® A
MAKROLON® GP Matte	Matte texture for privacy glazing	N/A	N/A
MAKROLON® GP Pebble	Pebble patterns for privacy glazing	LEXAN 90318 P.A.G.	TUFFAK A P-66
MAKROLON® FD	FDA compliant material	LEXAN 9440	TUFFAK T
MAKROLON® FI	Flame inhibiting grade	LEXAN 9600	N/A
MAKROLON® FI	Flame inhibiting	LEXAN 1200	TUFFAK FI-8
MAKROLON® SL	Thermoformable enhanced UV resistance	LEXAN SG 100	TUFFAK XL
MAKROLON® AR	Abrasion & UV resistance	LEXAN MarGard	TUFFAK CM-2
MAKROLON® CG 375	Physical attack resistant	LEXGARD® MPC 375	N/A
MAKROLON® CG 500	Physical attack resistant	LEXGARD MPC 500	N/A
MAKROLON® CG 750	Physical attack resistant	LEXGARD RC 750	N/A
MAKROLON HYGARD® 750	Bullet resistant	LEXGARD MP 750	N/A
MAKROLON HYGARD® 1000	Bullet/physical attack resistant	LEXGARD MP 1000	N/A
MAKROLON HYGARD® 1250	Bullet/physical attack resistant	LEXGARD SP 1250	N/A
MAKROLON® WG	Window Grade–high impact strength	Westlack Zelux	
MAKROLON® TG	Optically clear, enhanced abrasion & UV resistance	LEXAN FRA460, FRA236	

Lexan and Lexgard are registered trademarks of General Electric Corp.
Tuffak is a registered trademark of AtoHaas.

LIGHT AND ENERGY TRANSMITTANCE

By allowing up to 90% of solar energy and 88% of visible light through, clear MAKROLON Polycarbonate Sheet is an excellent glazing material for applications designed to maximize solar gain. In areas of solar intensity where higher shading or privacy is required, tinted materials may be used.

Light Transmission (Initial)

	Clear		Bronze or Gray	
Gauge	Visible	Solar Energy	Visible	Solar Energy
3/32″	87%	90%	50%	58%
1/8″	86%	89%	50%	58%
3/16″	84%	88%	50%	58%
1/4″	82%	86%	50%	58%

Technical Information

TYPICAL MAKROLON® GP POLYCARBONATE SHEET PROPERTIES

Property	MAKROLON	Units	Test Method
General			
Specific gravity	1.2	-	ASTM D-792
Water Absorption 24 hrs.	0.15	%	ASTM D-570
Refractive Index	1.586	-	ASTM D-542
Mechanical			
Tensile Strength, Yield, .125″	9,000	psi	ASTM D-638
Tensile Strength, Ultimate	9,500	psi	ASTM D-638
Tensile Modulus	345,000	psi	ASTM D-638
Shear Strength	6,000	psi	ASTM D-732
Compressive Strength	12,500	psi	ASTM D-695
Flexural Strength at 5% Strain	13,500	psi	ASTM D-790
Flexural Modulus .125″	345,000	psi	ASTM D-790
Izod Impact Notched .125″	12-16	ft.lb/in of notch	ASTM D-256
Rockwell Hardness	118	R Scale	ASTM D-785
Gardner Impact 1/2″ Diameter Dart .125″	>320	in.lbs	ASTM D-5420
Instrumented Impact .125″	>45	ft.lbs	ASTM D-3763
Thermal			
Heat Deflection Temperature 264 psi	270	°F	ASTM D-648
Heat Deflection Temperature 68 psi	280	°F	ASTM D-648
Coefficient of Thermal Expansion	3.75×10^{-5}	in/in/°F	ASTM D-696
Coefficient of Thermal Conductivity	1.35	BTU/hr/ft²/°F	ASTM D-177
Smoke Density	68	-	ASTM D-2843
Shading Coefficient Clear .125″	1.02	-	ASHRAE
Shading Coefficient Gray/Bronze .125″	.70	-	ASHRAE
Shading Coefficient Dark Gray .125″	.58	-	ASHRAE
Brittle Temperature	-200	°F	ASTM D-746
Flammability			
Horizontal Burn, AEB .125″	<1	in	ASTM D-635
Horizontal Burn, ATB .125″	<1	min	ASTM D-635
Self Ignition Temperature	1070	°F	ASTM D-1929
Flash Ignition Temperature	800	°F	ASTM D-1929
UL 94 Clear ≥ .060″	V-2	-	UL 94
UL 94 Clear ≥ .250″	V-0	-	UL 94
Optical			
Transmittance Clear .125″	>88	%	ASTM D-1003
Haze Clear .125″	<1	%	ASTM D-1003
Electrical			
Dielectric Constant 10 Hz	2.96	-	ASTM D-150
Dielectric Constant 60 Hz	3.17	-	ASTM D-150
Volume Resistivity	8.2×10^{16}	ohm-cm	ASTM D-257
Dissipation Factor 60 Hz	0.0009	-	ASTM D-150
Dissipation Factor 1 MHz	0.010	-	ASTM D-150
Arc Resistance			
Stainless Steel Strip Electrodes	10-11	sec	ASTM D-495
Tungsten Electrodes	120	sec	ASTM D-495

COMPETITIVE EDGE

Sheffield Plastics Inc. sets rigid raw material requirements for its polycarbonate resins supplied by Bayer Corporation. These materials, coupled with state-of-the-art production and quality control technology, assure that the physical properties of MAKROLON Polycarbonate Sheet will meet or exceed any directly competitive product on the market today. When it's "Made with Mak", you really have a competitive edge.

Sheffield Plastics Inc. will not be responsible for the use of this information relative to actual application. Users must make their own determination of its suitability for their specific use. No warranty is made for the fitness of any product, and nothing herein waives any of the seller's conditions of sale.

DOCUMENTATION AND TECHNICAL SUPPORT

Specific product information, warranty details, and further information regarding proper fabrication and/or use of materials can be received by contacting your local MAKROLON Polycarbonate Sheet distributor or by visiting us at www.sheffieldplastics.com.

MAKROLON® POLYCARBONATE SHEET COMBUSTIBILITY

Although the least combustible glazing material, Polycarbonate Sheet will ignite when exposed to an ignition source over 800°F.

Environmental Resistance of MAKROLON® Polycarbonate Sheet

MAKROLON® POLYCARBONATE SHEET IS RESISTANT AT 70°F AND 0% STRAIN TO:

CHEMICALS:

Amyl Alcohol	Chromic Acid (20%)	Lactic Acid (20%)	Potassium Bromate	Sodium Chloride
Aluminum Chloride	Citric Acid (40%)	Magnesium Chloride	Potassium Bromide	Sodium Hypochlorite
Aluminum Sulfate	Copper Chloride	Magnesium Sulfate	Potassium Nitrate	Sodium Sulfate
Ammonium Chloride	Copper Sulfate	Manganese Sulfate	Potassium Perchlorate	Stannous Chloride
Ammonium Nitrate	Formic Acid (10%)	Mercuric Chloride	Potassium Permanganate	Sulfur
Ammonium Sulfate	Formalin (30%)	Nickel Sulfate	Potassium Persulfate	Sulfuric Acid (10%)*
Antimony Trichloride	Glycerine	Nitric Acid (10%)	Potassium Sulfate	Sulfuric Acid (50%)
Arsenic Acid	Heptane	Nitric Acid (20%)	Silicone Oil	Tartaric Acid (30%)
Butyl Alcohol	Hydrochloric Acid (10%)	Oleic Acid	Silver Nitrate	Zinc Chloride
Calcium Nitrate	Hydrogen Peroxide (30%)	Oxalic acid	Sodium Bicarbonate	Zinc Sulfate
Chlorinated Lime Paste	Hydrofluoric Acid (10%)	Pentane	Sodium Bisulfate	
Chrome Alum	Isopropanol	Phosphoric Acid (10%)	Sodium Carbonate	

*Sulfuric Acid at 1% attacks polycarbonate sheet

COMMON HOUSEHOLD MATERIALS MAKROLON® POLYCARBONATE IS RESISTANT TO:

CHEMICALS:

Borax	Joy Liquid Detergent	Rum
Cocoa	Insulating Tape	Salad Oil
Cement	Linseed Oil	Salt Solution (10%)
Chocolate	Liquor	Soap (Soft/Hard)
Cod Liver Oil	Milk	Table Vinegar
Cognac	Mineral Water	Tincture of Iodine (5%)
Coffee	Mustard	Tomato Juice
Detergents	Olive Oil	Vodka
Fish Oil	Onions	Washing Soap
Fruit Syrup	Orange Juice	Water
Grapefruit Juice	Paraffin Oil	Wine
Gypsum	Rapeseed Oil	

PETROLEUM PRODUCTS MAKROLON® POLYCARBONATE SHEET IS RESISTANT TO:

Compressor Oil	Spindle Oil
Diesel Oil	Transformer Oil
Kerosene	Vacuum Pump Oil
Refined Oil	

Note: Elevated temperature and/or strain significantly alters resistance to industrial petroleum products.

LIMITED RESISTANCE AT 70°F AND 0% STRAIN TO:

Antifreeze	Hydrochloric Acid (conc.)
Calcium Chloride	Milk or Lime (CaOH)
Cyclohexanol	Nitric Acid (conc.)
Ethylene Glycol	Sulfuric Acid (conc.)

MAKROLON® POLYCARBONATE SHEET IS NOT RESISTANT TO:

CHEMICALS:

Acetaldehyde	Benzyl Alcohol	Chlorobenzene	Formic Acid (conc.)	Phosphorus Trichloride
Acetic Acid (conc.)	Brake Fluid	Chlorothene	Freon (refrigerant/propellant)	Proplonic Acid
Acetone	Bromobenzene	Cutting Oils	Gasoline	Sodium Sulfide
Acrylonitrile	Butylic Acid	Cyclo Hexanone	Lacquer Thinner	Sodium Hydroxide
Ammonia	Carbon Tetrachloride	Cyclohexene	Methyl Alcohol	Sodium Nitrate
Ammonium Fluoride	Carbon Disulfide	Dimethyl Formamide	Nitrobenzene	Tetrahydronaphthalene
Ammonium Hydroxide	Carbolic Acid	Ethane Tetrachloride	Nitrocellulose Lacquer	Thiophene
Ammonium Sulfide	Caustic Potash Sol. (5%)	Ethylamine	Ozone	Toluene
Benzene	Caustic Soda Sol. (5%)	Ethyl Ether	Phenol	Turpentine
Benzoic Acid	Chloride	Ethylene Chlorohydrin	Phosphorus Hydroxy	Xylene

MAKROLON® POLYCARBONATE SHEET IS DISSOLVED BY:

Chloroform, Cresol, Dioxane, Ethylene Dichloride,Methylene Chloride, Pyridine

EFFECTS OF MOISTURE ON MAKROLON® POLYCARBONATE SHEET:

MAKROLON Polycarbonate Sheet has good resistance to water up to approximately 150°F. Above this temperature, the effect of moisture is time-temperature related. Exposing MAKROLON Polycarbonate Sheet to repeated steam cleaning or dishwashing can create hydraulic crazing. The result can be a clouding of the surface and ultimately a loss of physical strength properties.

"Made with MAK", None Tougher, None Clearer MAKROLON® Polycarbonate Sheet...

BROAD RANGE OF PRODUCTS FOR THE MOST DEMANDING APPLICATIONS

From lofty barrel vault skylights exposed to extreme sunlight to street level signs that require resistance to graffiti and vandalism...from precision machined parts to the simple toughness of domed playground windows, there is a MAKROLON® Polycarbonate Sheet product that's right for your application. Ensuring optimum transparent sheet performance, MAKROLON HYGARD® Laminates offer unsurpassed protection from ballistic and physical attack in bullet-resisting and containment glazing applications.

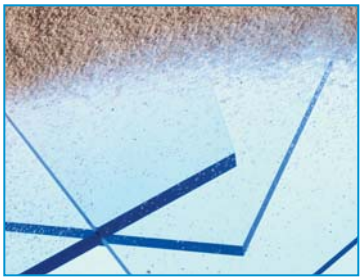
For detailed product or limited warranty information on any Sheffield Plastics sheet product please call: 800/254-1707, or visit our web site at www.sheffieldplastics.com.

MAKROLON® GP Polycarbonate Sheet

Standard MAKROLON GP Polycarbonate Sheet is backed by a limited warranty against breakage. This limited warranty applies to glazing sheet installed and cleaned according to the manufacturer's recommendations. If failure occurs within the warranty period, the purchaser will receive a free replacement of MAKROLON Polycarbonate Sheet when the failed sheet, original sales receipt and warranty are provided to Sheffield Plastics or the original distributor or dealer. Sheffield Plastics reserves the right to refund the original purchase price of the sheet in lieu of a replacement sheet.

MAKROLON® SL Polycarbonate Sheet

MAKROLON SL Polycarbonate Sheet is backed by a limited warranty against loss of light transmission and excessive yellowing. This limited warranty applies to glazing sheet installed and cleaned according to the manufacturer's recommendations.



MAKROLON® AR Polycarbonate Sheet

MAKROLON AR Polycarbonate Sheet is backed by a limited warranty against breakage, loss of light transmission, excessive yellowing, and coating failure. This limited warranty applies to glazing sheet installed and cleaned according to the manufacturer's recommendations. If failure does occur, as defined in the actual warranty, the purchaser will receive a free replacement MAKROLON AR Polycarbonate Sheet when the failed sheet, original sales receipt and warranty are provided to Sheffield Plastics or the original distributor or dealer. Sheffield Plastics reserves the right to refund the original purchase price of the sheet in lieu of a replacement sheet.

MAKROLON HYGARD® LAMINATES

All MAKROLON HYGARD laminated products are backed by a limited warranty against structural delamination, coating failure, loss of light transmission, and excessive yellowing. This limited warranty does not apply to product that has been physically or ballistically attacked or damaged, nor does it apply to improperly fabricated or maintained material.

Curbell Plastics is a proud supplier
of Sheffield materials

CURBELL PLASTICS Nationwide
1.888.CURBELL
www.curbellplastics.com

MAKROLON®
Polycarbonate Sheet is:
"Clearly the Right Choice"
for Any Application

For More Information Please Contact...

Sheffield Plastics Inc.
Customer Service Department
Phone: 800-254-1707
FAX: 800-457-3553
www.sheffieldplastics.com
E-mail: info@sheffieldplastics.com

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SYSTEM CERTIFICATION ISO 9001:2000 SGS

Sheffield Plastics Inc.
A BAYER Bayer MaterialScience Company

119 Salisbury Road
Sheffield, MA 01257
800-254-1707
Fax: 800-457-3553
www.sheffieldplastics.com
E-mail: info@sheffieldplastics.com

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